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AKAMAI INTERNSHIP PROGRAM

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Final Report

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14. ABSTRACT The Akamai Internship Program, a major component of the Akamai Workforce Initiative (AWI), addressed workforce needs in Hawai'i, where workforce shortfalls have the potential to impede U.S. leadership in astronomy and space surveillance, and the situation exemplifies problems faced by many large, remotely located facilities. Construction of the Daniel K. Inouye Solar Telescope (DKIST) has begun on the summit of Haleakala (Maui), and ground breaking for the Thirty Meter Telescope (TMT) International Observatory on Mauna Kea (Hawai'i Island) is planned for this fall. Workforce needs for both telescopes have been increasing, and affect all existing facilities and projects, including the Maui Space Surveillance Complex and sub-contractors that carry out maintenance, operation, and R&D for the Air Force. Since its inception, AWI has prioritized inclusion of people from diverse backgrounds, especially those from groups underrepresented in STEM. Through this project, a long-term retention of >80% of Akamai undergraduate interns in STEM degrees and careers has been accomplished, an important outcome when compared to national STEM graduation rates (<40%). More than 100 alumni are now in STEM jobs (2/3 in Hawai'i), and a steady flow continues to enter the workforce.						
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Final Report: 2010-2014 Akamai Workforce Initiative

Grant #FA9550-10-1-0044

Major goals of the project

This project builds on a long history of workforce development in science, technology, engineering and mathematics (STEM) related to astronomy, remote sensing, and Air Force related facilities in Hawaii. The Akamai Workforce Initiative (AWI) was developed by the Center for Adaptive Optics (CfAO) education program, headquartered at University of California Santa Cruz (funded by NSF Science & Technology Center program, AST-9876783). It began as “Akamai” – which means smart or clever in Hawaiian – in 2002 when a small group of leaders convened by the CfAO met on Maui and launched a new partnership aimed at increasing Maui’s capacity to develop a local workforce. The CfAO had just piloted a new model program that was carefully designed to advance college students into science and technology careers, and the first action of the new partnership was to pilot this model on Maui in 2003. This became the first cohort of the Akamai Internship Program, which has continued every year since then. In addition, plans for a new four-year degree program in engineering technology began and became the long-term goal of the partnership. In 2004 Akamai expanded to Hawaii Island in a partnership with W.M. Keck Observatory that soon engaged all the major Mauna Kea observatories. Akamai continued to grow and was funded for many years by the CfAO, and is considered to be an important legacy of the center.

In 2007, when the end of CfAO’s NSF funding was in sight, the National Science Foundation, the Air Force Office of Scientific Research (AFOSR), and the University of Hawaii all began investing in Akamai. Akamai’s administrative home shifted to the Institute for Astronomy (IfA) and new headquarters were established at the IfA Advanced Technology Research Center in Pukalani, Maui. UC Santa Cruz continued to play a major role in Akamai. At about the same time, UC Santa Cruz made a commitment to institutionalize CfAO’s successful education program, which became the Institute for Scientist & Engineer Educators (ISEE), and home to CfAO’s intellectual property. This grant, along with a grant from the NSF (#AST-0836053) utilized the CfAO/ISEE infrastructure in place to expand, scale-up, and make new contributions. With this new infusion of resources, the specific goals of the project were to:

- Prepare local students for careers in STEM, in particular for Hawaii’s AF related and relevant activities
- Increase the capacity of the Hawai’i scientific and technical community to teach diverse learners and design effective research experiences and laboratory courses.
- Increase the participation of women, Native Hawaiians, and other underrepresented groups in engineering technology education and employment in Hawai’i.
- Expand and enhance workforce development capacity in Hawai’i through engagement of employers and the current workforce

Major Activities:

AWI includes the following five interwoven components:

1. Professional development
2. Internships
3. Development of a new degree program
4. Industry network
5. Research & development

The weaving together of these components through a model developed by the CfAO is a central feature of AWI. Early career scientists and engineers (primarily graduate students and postdocs) participate in programs that prepare them to be effective and inclusive educators, and put what they learn into practice by teaching or mentoring undergraduates (see Attachment 1). The productivity of AWI comes from the utilization of a well-established education infrastructure, sustained effort to improve and scale up programs using evidence-based approaches, and rigorous studies that create new knowledge in the field of STEM workforce development, all seamlessly interwoven. ISEE's programs, unique research and development group, and the network of employers from Hawaii's observatories, companies, and government facilities were already well established. With funding from this grant and other sources, AWI was able to make a major contribution to the STEM workforce in Hawaii. In addition, new needs and unsolved problems were addressed, capacity was built, and studies were conducted that could only be accomplished by the continuity afforded by long-running CfAO/ISEE programs. This section includes a brief summary of how the major activities were utilized and improved.

1. Professional development of scientists and engineers

ISEE leads a national effort to improve STEM education and workforce development by transforming how the next generation of scientists and engineers teach and mentor. This objective addresses problems in STEM education at the source: how colleges and universities teach STEM affects the STEM workforce, public STEM literacy, and K-12 teachers. Because today's graduate students are tomorrow's college and university instructors, preparing them to be effective, inclusive educators will make lasting change. In addition, many graduate students will enter non-academic jobs, where they will be mentors and contribute to working environments that also need change to be more inclusive. Unfortunately, there are very few programs like ISEE, and graduate students are trained in the way that their professors were, perpetuating the cycle.

ISEE's Professional Development Program (PDP) prepares STEM graduate students, postdocs, and others professionals to be effective, inclusive educators. The program also develops professional skills that broaden participants' career options. Participants in the PDP attend two intensives, and then work on a small team to design and teach an instructional unit, with ongoing support from PDP instructors (for details see "professional development opportunities"). They typically spend 100 hours each year they participate, carefully and intentionally designing an inquiry activity. An essential element of the PDP is the teaching experience. Unlike many workshops and courses, all PDP participants put

what they learn into practice. ISEE's PDP is much more than a program. It is a dynamic, continually evolving community of scientist- and engineer-educators who utilize the PDP infrastructure to innovate and grow. In addition to directly training 116 participants during the project period, refinements were made, solutions to ongoing program challenges were implemented, capacity was expanded, and objective measurements of the PDP's impact were made.

2. Internships to engage college students in authentic projects and practices

To directly contribute to developing a diverse, local STEM workforce, the initiative utilized the Akamai Internship Program, a program developed by the CfAO/ISEE. College students from Hawaii are recruited and then placed at Maui industry and Big Island observatory sites, where they complete an authentic workplace project under the guidance of a mentor. The carefully designed model focuses on engaging student interns with an authentic project in the workplace, first preparing them in an intensive course taught by PDP participants, and then throughout their experience through weekly meetings and communication assignments. Key to this experience is that each student has a productive project – one that balances educational outcomes for the intern with the authentic needs of the internship site. The model of this program is shown in Attachment 2, along with outcomes (also included in the “impact” section of this report). During the project period, 112 interns joined the program.

In addition to directly supporting students in the program, this project supported studies, development of new tools, and refinements of strategies that have positioned the program to scale up. A longitudinal study combined cohorts from CfAO/ISEE and AWI to analyze persistence rates and relate them to demographics and aspects of students' experience in the program. New tools and activities were developed to support more effective mentoring, including a research-based framework and set of tools to help mentors design and guide students in productive projects.

3. Development of a new engineering technology 4-year degree program

As envisioned in 2002, an Engineering Technology Bachelor of Applied Science (BAS) degree is now offered at University of Hawaii Maui College (UHMC), stimulating institutional change from a 2-year to 4-year degree college. As described in the “impacts” section of this report, the curriculum, courses, articulation agreements, student monitoring processes, and approval process were all accomplished through this project. The overall program, and several targeted courses were designed with four focused curricular inputs: workforce needs, inquiry, equity, and Hawaii socio-cultural context. Twenty-six students have enrolled in the program to date; eight have graduated; and six of the eight graduates are employed in STEM jobs on Maui. Maui is a small community, and the number of students served by this program are correspondingly small, but the program fills an extremely important need, and will continue as a new institutionally supported program.

4. Industry network

The authentic engagement of the current workforce and employers in AWI activities is a hallmark of the initiative that keeps activities grounded in addressing authentic workforce needs, and mobilizes those that are in the current workforce to help prepare the next

generation. Building on CfAO's decade of work with companies, observatories, government entities, higher education institutions, and community organizations, the network was expanded, and structured in new ways to have a greater impact. New career development workshops directly involving industry membership were designed and implemented. Through focus groups, interviews, and working sessions, the project established the most important entry level skills, developed new mentoring workshops, and demonstrated the ways that students can contribute to real problems at industry/observatory sites (see Attachment 2).

5. Research & development

AWI utilizes ISEE's unique research and development group to develop and implement objective assessment and evaluation tools, generate new knowledge on education and workforce development, and translate research into practice. With support from this grant, curricular inputs (workforce needs, inquiry and equity) were translated into tools that can be used for curriculum and professional development, which are now used broadly in ISEE for professional development. As stated above, a longitudinal study of internship outcomes was conducted. Combining results with prior CfAO studies on the same program model, new knowledge has been generated about effective mentoring, including findings that have practical implications for formal undergraduate education. Finally, using the results of these studies, and the research findings of others, new tools and workshops were designed to support more effective mentoring.

Significant results

This section of the report focuses on what has been learned from the project that informs the field of STEM workforce development. Building on CfAO/ISEE's long history and infrastructure, evaluation, assessment and research studies were conducted, that provide new perspectives on workforce development. Examples of findings in two major areas are described below:

1. Addressing STEM workforce needs by retaining today's college students

1A. STEM persistence rate of 79%

To date, 222 college students from Hawaii have participated in the Akamai Internship Program (112 during this project plus 110 supported by CfAO). The students are diverse and reflective of the demographics of the state of Hawaii: 23% identify as Native Hawaiian/Pacific Islanders, 52% as being from underrepresented minority groups, 42% as women, and 37% community college students. The program focuses on early engagement of college students: 57% of participants in the internship program had only finished their freshman or sophomore year. The majority of students participating in the program are in engineering, computer, and technology focused majors, which often have persistence rates of less than 40%. More than 90% of alumni from the program were located in order to learn about their education and career progress; 79% of participants persisted in STEM

three years after entering the program, either entering the STEM workforce or enrolled in a STEM program of study.

1B. Underrepresented and majority groups persist at same rate

Chi-square tests were performed to determine whether there were differences in persistence rates for students with different background characteristics, which other studies have shown to be correlated with differences in STEM persistence rates, and/or college persistence rates in general. The persistence rate of men and women in our program were statistically the same ($p = 0.49$), as were persistence rates of those from underrepresented minority groups versus majority groups ($p = 0.21$). We devised a scheme to code for students' family's college experience from 1-9 and similarly looked for a correlation to whether students persisted or not, and there was no statistically significant difference: $F(1, 247) = 1.003$, $p = 0.31$. These results are important not only because they provide clear evidence of the program's effectiveness, but also because they suggest that the students' persistence in STEM is more about their experience in college directly than their background.

1C. Students' college GPA was not a predictor of persistence in STEM

Students accepted into the Akamai Internship Program enter with a wide range of backgrounds, including a great deal of variation in their prior academic performance, as measured by their grade point average (GPA). The GPA range of students accepted is typically 2.5-4.0; the median GPA is 3.3. In other words, the program does not just take the highest performing students, but accepts many students who are earning B and C grades. The selection process considers grades but looks at many other things; an indication that the student is motivated, hardworking, dependable, and able to work on a team holds more weight than earning A's in courses. The difference in GPA for those who persisted in STEM (mean = 3.40) and those that did not (mean = 3.32) was not statistically significant, $F(1, 241) = 1.13$, $p = .29$. There are two important aspects to these findings: 1) many high performing students, who start college intending to pursue a STEM degree, leave STEM, not just those who are under-performing; and 2) students who earn B's and C's persist and successfully enter the workforce. Given the increasing demand for a U.S. STEM workforce – at multiple degree levels, not just PhDs – these findings suggest a closer look at why high performing students leave STEM, and a broader view of who can be successful in a STEM career, and what the degree pathways are.

1D. How students' projects are designed, and mentor-student interactions are important

The ISEE research & development group conducted a study that explored whether there was any correlation between students' self-reported experience in the program and their persistence in STEM. At the end of the program each year, students were given a survey that asked them to report on their experience, such as how they valued various aspects of the program (short course, experience at their internship site, overall program) and some questions more specifically about their project. The only question that showed any correlation to whether students persisted in STEM was a question about the level of challenge provided by their project. Students who perceived their project to be "challenging" were more likely to persist in STEM, compared to those who perceived their

project as “not being challenging enough.” Though this is just one question, it becomes more compelling when combined with earlier studies conducted by the CfAO, in which findings indicated that a student’s project and mentor-student interactions had a significant impact on the students’ experience. These findings inform the field of mentoring – an extremely important part of workforce development – that has largely focused on everything except the trainee’s actual STEM work, which is the vast majority of their experience in internships.

2. Effective professional development of early career scientists and engineers

2A. Competency in designing an inquiry learning experience

All PDP participants design, teach and assess an inquiry activity. In a study carried out during this project, an assessment tool was developed to identify specific, observable “inquiry indicators” to assess how well participants accomplished this task. Findings indicated that 70% of participant teams demonstrated a high level of proficiency. The other 30% were still considered a significant improvement over how activities are usually taught, but had some shortcomings, in either their design or their documentation, that excluded it from the high standards held within the PDP.

2B. Effective professional development takes multiple cycles of learning, practice and reflection

In the above study, there was a moderate positive correlation between the “inquiry indicator” score and the leaders’ year in the PDP ($r = 0.46, p < 0.10$). This matches what we have observed for many years: *it is usually in the second cycle of the PDP that participants gain a solid understanding of how to design an inquiry activity*. Interestingly, participants’ *self-reported* assessments of the designs were weakly *anti-correlated* with this – highlighting the importance of using objective measurements to assess an instructors’ implementation of new teaching practices. This finding aligns with others who have found that participants’ self-reported teaching practices often do not match what they do.

2C. Improved understanding of inclusive teaching strategies

Another study was conducted during this project to objectively assess participant gains in their understanding of inclusive teaching strategies. A tool and protocol were developed to score pre and post responses to a question that prompted participants to give specific examples of strategies they would use. Findings indicated a statistically significant pre-post difference in participants ($p < 0.01$) and retention of knowledge a year later (see “publications”).

2D. Learning gains from PDP participants’ learners

The goal of professional development is for educators (who are the ones getting the professional development) to teach effectively. The most compelling evidence for demonstrating this comes from assessing whether their learners actually gain what the educator had intended. All PDP participants assess their learners in relation to their intended learning goals, and we gather this evidence. During this project we also conducted several pre-post assessments of PDP participants’ learners, and found statistically significant gains in their understanding of (e.g. of light and optics).

Key outcomes:

In this section, key outcomes are summarized in relation to the major goals of AWI:

- Increase the participation of women, Native Hawaiians, and other underrepresented groups in engineering technology education and employment in Hawai'i.
- Prepare local students for careers in STEM, in particular for Hawaii's AF related and relevant activities
- Increase the capacity of the Hawai'i scientific and technical community to teach diverse learners and design effective research experiences and laboratory courses.
- Expand and enhance workforce development capacity in Hawai'i through engagement of employers and the current workforce

Increase the participation of women, Native Hawaiians, and other underrepresented groups in engineering technology education and employment in Hawai'i.

- The Akamai Internship has served 222 Hawaii students to date, and 112 in the project period, reflecting the diverse population of Hawaii:
 - 23% Native Hawaiian
 - 48% underrepresented minority group
 - 37% women
 - 37% community college students
 - 60% born in Hawaii
 - 80% born in Hawaii or graduated from Hawaii high school
- Akamai internship alumni stay on a STEM career pathway: 81% of alumni are continuing their STEM education or in the STEM workforce, across all gender and ethnic groups

Prepare local students for careers in STEM, in particular for Hawaii's AF related and relevant activities:

- 93 Akamai alumni are now in full-time STEM jobs – many in Hawaii.
- The National Solar Observatory has hired Akamai alumni
 - 8 short-term hire
 - 1 permanent hire – a thermal engineer working for ATST on Maui
- Students in the UHMC 2-year Associate's program are moving into the new 4-year BAS program: on average, 43% of AS graduates enter the BAS program
- A total of 20 students started the UHMC BAS program between 2010-2012; 8 have graduates and another 6 are still working on their degree, for a persistence rate of 70%

(and an additional 6 enrolled in Fall 2013)

- 6 of the 8 BAS graduates are employed in tech jobs on Maui (Boeing, Pacific Defense Solutions (3 hired), Ardent, and Enterprise

Increase the capacity of the Hawai'i scientific and technical community to teach diverse learners and design effective research experiences and laboratory courses.

- 116 scientists and engineers have been trained through the ISEE PDP
- 15 current University of Hawaii faculty members have been trained through the ISEE PDP
 - 1 at UH Hilo
 - 2 at Hawaii Community College (1 now retired)
 - 2 at Kauai Community College
 - 5 at UH Maui College
 - 5 at UH Manoa
- 25 mentors have been trained in effective mentoring techniques

Expand and enhance workforce development capacity in Hawai'i through engagement of employers and the current workforce

- AWI has partnerships with all the major current and future major telescopes in Hawaii, and they all are actively engaged in workforce development by training interns
- AWI has partnerships with many companies related to astronomy and remote sensing on Maui and Hawaii Island
- Each year, AWI works with 30-40 professionals currently in the workforce, helping them to define projects and consider ways to provide a good experience for their intern
- AWI's industry/observatory network is actively engaged in defining workforce needs (which have been published), conducting mock interviews, and participating in many other career development events

Training and professional development provided by the project

1. ISEE Professional Development Program

Professional development is a significant component of this project. AWI participants were able to participate in the ISEE Professional Development Program (PDP). Overall, 376 participants have been in the PDP. Through this project, 116 scientists and engineers were trained through the PDP. Through a combination of training existing University of Hawaii (UH) faculty, and trained PDP alumni gaining new positions at UH, 15 current UH faculty are alumni of the PDP. Additional participant outcomes are given in the “impacts” section of this report.

The ISEE Professional Development Program (PDP) is a flexible, multi-year program for scientists and engineers at the early stages of their careers, with a primary focus on graduate students. Participants receive training through two intensives, work on a team to collaboratively design an inquiry activity, and then put their new teaching skills into practice in “teaching labs” — ISEE-affiliated educational programs or courses. The PDP has been running since 2001, and has now had nearly 400 participants, many of whom have returned to the program for more than one year. A volume published on the PDP includes 45 papers written by participants, instructors, and others in the PDP community. Alumni of the program are now in academic and non-academic STEM positions throughout the U.S. and internationally. Alumni report that they gain:

- Teaching and learning experience that is transformative
- Enhanced teaching qualifications that land jobs, awards, and promotions
- Improved professional skills (leadership, project management, communication)
- An advantage in fellowship and grant applications
- Unique experience in how to teach through inquiry
- A practical understanding of research on how people learn
- Strong foundation that supports many teaching and mentoring strategies
- A community that is dynamic, enduring, and rare

2. Professional development for mentors: Our work in the area of mentoring is an example of how we integrate R&D into our practice. Through our research findings, we have developed a unique focus on “explanation” and “STEM identity”, as well as a nuanced understanding of skills needed by the Hawai’i astronomy workforce. Our network of mentors has expressed strong interest in receiving mentoring training, and so we have drawn from our resources (such as our library of recorded mentor-intern and instructor-learner interactions) to develop mentoring tools (e.g., an inventory of mentoring strategies). In collaboration with our most engaged mentors, and with funding through the Akamai Workforce Initiative, and our partner, the Thirty Meter Telescope (TMT), we have developed and piloted frameworks, tools, and workshop components. Workshops are offered to mentors from Maui and the Big Island, and approximately 25 have been through the workshops to date.

Disseminating of results to communities of interest

In the Governor of Hawaii's "State of the State" speech, the Akamai Workforce Initiative was mentioned

Three technical reports were published

Eleven publications related to PDP curriculum published and regularly distributed

Activities have been featured in two newsletter issues of the "ISEE Exchange"

Presentations have been given to many national audiences, including: National Science Foundation, National Solar Observatory, Association of Universities for Research in Astronomy, Thirty Meter Telescope, and Air Force Office of Scientific Research. Many presentations in the state of Hawaii, including University of Hawaii campuses and system, Hawaii Community Foundation, observatory, advisory committees, Native Hawaiian STEM Mentoring Program, Society of Women Engineers, and many others.

Student symposia that include many industry, academic and observatory partners

Other presentations at meetings and local events

Informational visits were regularly made to:

- Electronic Technology Hawaii Community College
- Information & Computer Science, Kapiolani Community College
- STEM Club Kauai Community College
- Computing, Electronics, and Networking Technology, Honolulu Community College
- UH Manoa - Native Hawaiian Science and Engineering Mentorship Program
- UH Manoa - Society of Women Engineers
- UH Hilo Computer Science Program
- Mauna Kea Observatories
- Maui tech companies

Project Impact

1. Impact on the development of human resources: retention on STEM Pathway

Akamai tracks students each year to learn about and monitor their educational and career progress. 87% (194 of 222) of alumni of the 2003-2012 internship programs were located in Year 4. Of those located, 47% are now in STEM jobs, 23% are in STEM undergraduate programs, and 12% are in graduate programs. In total, **82% are on a STEM pathway** – either in a STEM job or enrolled in a STEM program. A particularly notable outcome is that there does not appear to be any significant difference in retention between students of

different ethnic or gender groups (see attachment). We have also determined the status of alumni who entered the program at **least three years earlier** to see the longer-term impact of the program. There were a total of 142 alumni from 2003-2009, and we were able to obtain the status of 132 of them (93%). **For alumni completing the program at least three years prior, 79% are on a STEM pathway.**

2. Increasing the capacity of the Hawai'i scientific and technical community to teach diverse learners and design effective research experiences and laboratory courses

Professional Development Program

The PDP, originally developed through the NSF Center for Adaptive Optics, and now run through the Institute for Scientist & Engineer Educators (ISEE) and the Akamai Workforce Initiative (AWI), prepares early career scientists and engineers for future faculty positions and simultaneously transforms undergraduate education. The PDP focuses on inquiry teaching and learning, and inclusive teaching strategies for supporting diverse learners – and how inquiry, diversity, and equitable learning are linked. Participants in the PDP design and teach their own inquiry unit, learn and employ a wide range of learner-centered teaching strategies, and reflect within a community of practice.

All participants design an “inquiry” – an activity that mirrors authentic STEM practice – that creates an equitable learning environment. Most participants spend on the order of 100 hours each time they participate in the PDP; many come back for a second, third, or more times. They carefully design one unit, team-teach it, and reflect. It intended to be a transformative experience that participants will draw on throughout their career.

In thirteen years, the PDP has trained 350 participants who have designed 90 inquiry activities. The PDP has demonstrated outcomes in the knowledge, skills, and attitudes of participants *and* of the diverse learners participants teach in affiliated programs and courses. Many of the measures of PDP outcomes are objective measures rather than self-reports. For example, our research shows that undergraduate students are better prepared to take initiative in professional settings after engaging in inquiry activities designed and taught by PDP participants. Our studies also show that PDP training improves participants' understandings about inclusive teaching. Our volume published in 2010 includes many more examples of PDP outcomes, but one of the most important is the impact on STEM undergraduate education nationally. A total of 66 PDP alumni who began the program as graduate students or postdocs are now in professional positions. There are now 38 PDP alumni in long-term academic positions across 15 states, as well as two in other countries (see map in attachment).

3. New infrastructure at University of Hawaii Maui College & the Institute for Astronomy

A major component of this grant included developing an Engineering Technology Bachelor's of Applied Science (ENGT BAS) at University of Hawaii Maui College (UHMC). The program officially started in fall 2010 with its first cohort. This new program has

significantly enhanced the institutional infrastructure of UHMC. A summary of this infrastructure includes:

New Courses: In 2009 the Engineering Technology Bachelor's of Applied Science degree was approved. Fifteen new courses were developed and approved, including: Calculus for Engineering Technology, Physics for Engineering Technology, Engineering Computing, Applied Robotics, Intermediate Optics, Signals & Systems, Optoelectronics, Power Systems, Signal Processing, Electro-Mechanical Control Systems, Project Management, Remote Sensing, Advanced Instrumentation, Capstone Project I, and Capstone Project II.

Courses designed and taught by IfA: Two of the above courses were included in AWI funding to be intentionally designed using the core curricular elements and taught by IfA faculty:

- **Remote Sensing:** Course provided a rich array of hands-on activities engaging students in many different ways of learning and presenting their findings. Assessment was also very diverse and included oral presentations, written reports, performance assessments, and a range of different homework assignments. Students worked individually and in teams throughout the semester, and completed activities at the IfA Advanced Technology Research Center.
- **Advanced Instrumentation:** Applies students training in optics, mathematics and physics to understand some of the general principles of (primarily) remote sensing instrumentation – focused on how they work, how to maintain/calibrate such instruments, and how to work within a team to maintain, design and build new instruments. The course emphasizes active participation, working on diverse teams, communication.

Supporting student projects with laboratory infrastructure: Through AWI, a significant investment has been made in developing a laboratory infrastructure for UH Maui College students to have access and opportunities to complete projects at the IfA Advanced Technology Research Center. Laboratory facilities are well-aligned with the curriculum and will be able to support students' capstone projects for many years.

Articulation with statewide community colleges: AWI funds enabled the development of A UHMC – Kauai Community College articulation agreement which will allow their Electronics Technology AS graduates to enroll in the UHMC's BAS ENGT degree program. Meetings with Hawaii Community College, which is working on a new curriculum for the electronics program, were held and there is interest in developing a similar articulation agreement.

Student monitoring system: With funding from the AWI, UHMC launched a monitoring system, which tracks student progress and allows faculty to provide counseling and follow-up on any issues that are identified. Students meet with their advisor or counselor at the time they enroll in the ECET program and together they draft a two to three year academic plan, which then serves as a basis for meeting with faculty throughout their enrollment.

Increased laboratory capacity for 2-year program: The student electronics lab was increased from a capacity of 16 students to 24 students, and electro-optics lab from 8 to 17 stations. An advanced optics workstation with hardware and software for student use was also obtained. The partnership raised additional funding for other new equipment.

Hawaii ISEE Chapter: A legacy of this award is an active ISEE Chapter in Hawaii. Through the Chapter, Hawaii-based participants will be able to continue to participate in the PDP. There are currently three PDP instructors from Hawaii who serve on the overall ISEE PDP instructional team.

4. New infrastructure at University of California Santa Cruz

One of ISEE's major roles in the AWI project was to support the integration of core curricular inputs into the new UHMC program. This stimulated ISEE to make a number of professional development tools more accessible to participants in program, as well as the AWI team. In addition, ISEE developed and taught various units that could then be incorporated into the new program at Maui College. The core curricular inputs included:

- **Inquiry:** A framework has been published, and is available at: <http://isee.ucsc.edu/programs/pdp/inquiry.html>. Many inquiry units were designed and taught in UHMC courses, and have been published (see "publications").
- **Diversity & Equity:** ISEE has worked for many years on how to support diverse students and create equitable learning environments. With support from AWI funds and other sources, ISEE articulated five "focus areas" that support inclusive curriculum development, in particular at the higher education level. The focus areas have been published and are available at: <http://isee.ucsc.edu/programs/pdp/diversity-equity.html>.
- **Workforce needs:** As indicated above ISEE conducted a workforce needs assessment that has been published and organized into a framework that has informed curriculum development of the new program see: <http://isee.ucsc.edu/projects/ews.html>).
- **Social and cultural context:** ISEE's Diversity & Equity Focus Areas encapsulate many important aspects of this theme. For example, designing curriculum that supports the different ways that students learn and show their achievement. In addition, several specific units were developed to engage students in discussing the interplay between technology and society, and discussions about using sacred mountaintops for siting telescopes.

Contributions of the Akamai Workforce Initiative

OVERVIEW

The Akamai Workforce Initiative (AWI) is a program that seeks to develop a skilled local STEM workforce to meet the needs of Hawai'i's growing high-tech industry. Launched as an internship program in 2002, AWI today is the result of a long-term collaboration among the University of California Santa Cruz's Institute for Scientist and Engineer Educators (ISEE), the University of Hawai'i, local Hawaiian high-tech businesses, observatories, and U.S. Air Force facilities, and other higher education institutions.

This brief presents an external perspective on AWI and is authored by Inverness Research, a research group with more than 25 years of experience studying the design, implementation, and contributions of a wide range of educational improvement initiatives. Inverness collaborated with the leaders of ISEE and AWI to examine the returns on the long-term investment in AWI for this brief. These returns are described here in terms of:

- contributions to Akamai interns and the local STEM workforce
- broader contributions to Hawai'i's STEM workforce development and the next generation of scientists and engineers
- research findings that inform the broader field.

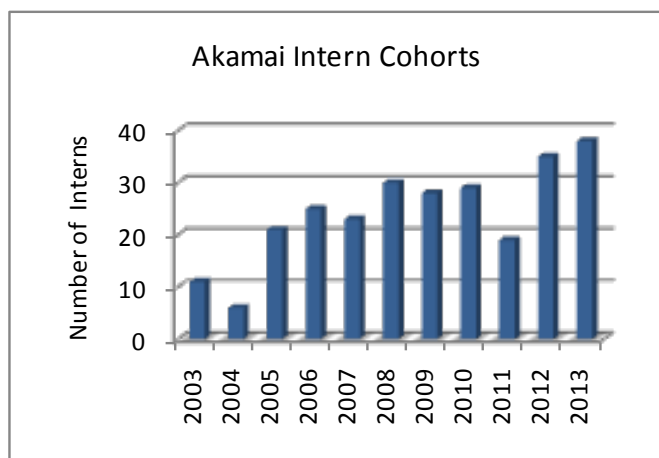
This brief is meant to complement two related briefs: [The UCSC Institute for Scientist and Engineer Educators](#), and [The Design and Evolution of the Akamai Workforce Initiative](#).

CONTRIBUTIONS TO AKAMAI INTERNS AND THE LOCAL STEM WORKFORCE

Hawai'i is home to numerous observatories, where the majority of the workforces are comprised of engineers and technicians. With ongoing national and international investments in building high-tech telescopes in Hawai'i (Thirty Meter Telescope, Daniel K. Inouye Solar Telescope), demand for workers with technical expertise continues to rise well above the available supply. Thus there is a serious need for a local workforce with high levels of scientific and technical skills. Over the past ten years AWI has been able to make a major contribution to the quantity and quality of the STEM workforce in Hawai'i, as demonstrated by the following evidence.

Akamai Interns

Akamai interns are college students from Hawai'i, selected on their potential to contribute to the local high-tech workforce. Eighty percent were born in Hawai'i or graduated from a Hawai'i high school, while only 20 percent came to Hawai'i to go to college. To date, 222 college students have participated in the Akamai Internship Program. Annual cohorts have grown over time, as shown in the graph to the right.



The demographics of Akamai interns are diverse, reflective of the population of the state of Hawai'i, and inclusive of groups underrepresented in STEM:

- 37% Women
- 23% Native Hawaiian/Pacific Islander (NHPI)
- 48% Underrepresented minority (NHPI and others)
- 37% Community college students
- 60% Born in Hawai'i
- 80% Born in Hawai'i or graduated from high school in Hawai'i

The majority of Akamai interns are from groups that historically have high attrition rates in college—they are not students who will “make it anyway.”

Unlike many “research experience” programs, Akamai accepts students early in their college education. Fifty-seven percent had just completed their freshman or sophomore year when they entered the program. Akamai also accepts from both 4-year and 2-year institutions—as noted above, 37% are from community colleges.

Local STEM Workforce

Intern placements are in fields with high workforce demands, where women and some minority groups are severely underrepresented, i.e., computer science, electronics, mechanical engineering, optical engineering, electrical engineering, and information technology.

- Based on a study of participants three years after entering the program, the vast majority (79%) of undergraduates who participate in AWI persist in either a STEM education program and/or move into a STEM career pathway.
- Ninety-six Akamai alumni are now in full-time STEM jobs. Nearly two-thirds of them are working in Hawai'i, contributing to the local STEM workforce.
- The Daniel K. Inouye Solar Telescope is hiring Akamai interns for short-term and permanent positions to establish a local workforce.

Akamai has generated many successful intern stories. There are many Hawai'i college students in the STEM pipeline who with support, training, and access have the potential to become valued members of the local workforce.

Akamai is a highly cost effective way of building the local workforce. Two summer projects and a career development workshop (see “One Intern’s Story” above) are just a fraction of the cost of relocating and training an engineer from the mainland—who is twice as likely to leave within three years.

The mentors of Akamai interns report on the real contributions the interns make to the projects they work on and to the success of the program:

These kids are doing more than menial work...they are doing real work of real value.

This (project) is really important because it demands the interns reach a certain higher level... if they are successfully to do work in this project. They need critical thinking skills and problem-solving skills that come from a lot of hands-on experience.

Akamai is to me a very effective and efficient use of our funding for workforce development. They just do it really well.

One Intern’s Story

James Linden grew up on Hawai'i Island, graduated from Waiākea High School, and then moved to O'ahu where he majored in mechanical engineering. In 2007 Linden was selected by the Akamai Internship Program and placed at Gemini Observatory. Under the mentorship of an engineer he created a computer model of a cooling system for a telescope instrument. In 2010 he attended an Akamai career development workshop sponsored by the National Solar Observatory (NSO). He spent the summer of 2011 in Arizona working at NSO, where they were so impressed with him that they hired him for a permanent position. Linden now lives on Maui and is a thermal technician for NSO's Daniel K. Inouye Solar Telescope (DKIST).

BROADER CONTRIBUTIONS TO HAWAI'I'S STEM WORKFORCE DEVELOPMENT AND THE NEXT GENERATION OF SCIENTISTS AND ENGINEERS

A major component of AWI is ISEE's Professional Development Program (PDP). The PDP immerses early career scientists and engineers (graduate students, postdocs, and professionals) in a professional development experience where they interact with college students in "teaching lab" environments such as the Akamai Internship Program, college courses, and other workforce development activities. ISEE and AWI have increased the local capacity of the universities in Hawai'i to contribute to the development of indigenous high-tech workers.

- A total of 116 AWI participants have completed the PDP, including 15 University of Hawai'i faculty members.
- Maui now has a 4-year degree program that prepares students for local tech jobs.
- University of Hawai'i (UH) Maui College has doubled the student capacity of its 2-year engineering technology degree.
- Six of eight graduates to date have tech jobs on Maui. In the small community of Maui, these numbers make a large difference.

Akamai has helped to create a local institutional infrastructure that helps meet the state's need for a high-tech workforce. New high-tech college training programs, new courses and laboratory facilities, carefully engineered internships, articulation with statewide community colleges, and an ISEE chapter in Hawai'i are some of the many mutually advantageous institutional relationships and structures built through the AWI investment.

Outcomes from integrating the PDP into AWI are summarized in more detail in a companion brief, [The UCSC Institute for Scientist and Engineer Educators](#).

The ISEE Professional Development Program has involved 240 active or "primary" participants for over a decade. These graduate students and postdocs learned to successfully integrate inquiry and inclusive teaching strategies into their own instruction. They have participated in and learned about generating and assessing learning objectives. They have gained professional skills including teamwork, mentoring, leadership, project management, and collaboration. A third have advanced into the STEM workforce (approximately 43 into academic positions; 32 into non-academic positions). The others are continuing their studies and will advance into careers soon.

RESEARCH FINDINGS THAT INFORM THE BROADER FIELD

In addition to directly supporting student participants and developing institutional infrastructure, AWI has supported research studies, development of new tools, and refinements of strategies that have positioned the program to inform the broader field of workforce development. Here we highlight just a few key ideas and tools of merit generated by AWI with the potential to inform other similar efforts and to spur the refinement of its own efforts.

Findings about Effective Professional Development

- In a study carried out within AWI by ISEE, an assessment tool was developed to identify specific, observable "inquiry indicators" that could assess how well ISEE's Professional Development Program participants accomplished designing, teaching, and assessing an inquiry activity. (More information about this tool and other papers about the PDP can be found at isee.ucsc.edu/publications/proceedings/volume-abstracts.html.)
- Using the inquiry indicator tool, research findings indicate that about 95% of PDP participants

integrate what they learn into their teaching experience, 70% with a high level of proficiency. This is important because very few professional development efforts are able to demonstrate such a high level of implementation, i.e., their participants put into practice the strategies they learn.

- ISEE experience has shown that effective professional development takes multiple cycles of learning, practice, and reflection. In the above study, there was a moderate positive correlation between the inquiry indicator score and the number of years the leader was involved in the PDP. These findings match what the project has observed for many years, namely, that it is usually in the second cycle of the PDP that participants gain a solid understanding of how to design an inquiry activity.
- A tool and protocol were developed as part of a study designed to assess PDP participants' gains in their understanding of inclusive teaching strategies. Using this tool, findings from a pre-post assessment indicated a statistically significant difference in participants' retention of knowledge about inclusive teaching strategies a year after their learning about the strategies.

Findings about Undergraduate Persistence in STEM

- Akamai interns of all ethnicities and of both genders persist in STEM careers at the same rate. There have been no gender or ethnicity-related differences as typically seen in college persistence rates.
- GPA upon entrance into the Akamai internship has not been a determining factor in the retention in STEM. The GPA of interns upon acceptance is from 2.2 to 4.0, with a median of 3.3. Interns with higher GPAs did not have a higher probability of staying in STEM.
- New knowledge about the relationship between the quality of the intern project and mentor-mentee relationships provides important lessons learned for the field of mentoring, as a quote from the AWI annual report suggests: *These findings inform the field of mentoring—an extremely important part of workforce development—that has largely focused on everything except the trainee's actual STEM work, which is the vast majority of their experience in the internship.*

SUMMARY STATEMENT

Evidence cited in this brief illustrates how AWI and ISEE have contributed in a wide range of ways. The programs have supported the development of individual interns, aided workforce development in Hawai'i, built institutional infrastructure, and created tools that build the knowledge base of the STEM education community. These contributions are all the direct result of the sustained, long-term commitment of ISEE and AWI.

Funding for AWI was provided from multiple sources over many years, including: National Science Foundation (AST-9876783, AST-0710699, AST-0836053, AST-0850532); Air Force Office of Scientific Research (AFOSR) (via NSF AST-0710699 and FA9550-10-1-0044); University of Hawaii Vice President for Research office; Thirty Meter Telescope International Observatory; National Solar Observatory; Air Force Research Laboratory Directed Energy Directorate. More information on AWI can be found at: akamaihawaii.org.

Visit the Inverness Research website at inverness-research.org/abstracts/ab2014-06_Rpt_Akamai_Briefs.html to view two related briefs: *The UCSC Institute for Scientist & Engineer Educators*, and *The Design and Evolution of the Akamai Workforce Initiative*.

Inverness Research, a national education evaluation and consulting group headquartered in Northern California, has over 25 years of experience studying local, state, and national investments in the improvement of education.

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Principal Investigator Name

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Lisa Hunter

Program Manager

The AFOSR Program Manager currently assigned to the award

Evelyn Dohme

Reporting Period Start Date

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Reporting Period End Date

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Abstract

The Akamai Internship Program, a major component of the Akamai Workforce Initiative (AWI), addressed workforce needs in Hawai'i, where workforce shortfalls have the potential to impede U.S. leadership in astronomy and space surveillance, and the situation exemplifies problems faced by many large, remotely located facilities. Construction of the Daniel K. Inouye Solar Telescope (DKIST) has begun on the summit of Haleakala (Maui), and ground breaking for the Thirty Meter Telescope (TMT) International Observatory on Mauna Kea (Hawai'i Island) is planned for this fall. Workforce needs for both telescopes have been increasing, and affect all existing facilities and projects, including the Maui Space Surveillance Complex and sub-contractors that carry out maintenance, operation, and R&D for the Air Force. Since its inception, AWI has prioritized inclusion of people from diverse backgrounds, especially those from groups underrepresented in STEM. The goals of the program are to advance local students into the tech workforce, and increase the participation of underrepresented groups in STEM. Akamai has a long-standing success for engaging and retaining underrepresented and under-served populations. Approximately 33% of Akamai

Internship alumni are community college students, 40% are women, 23% are Native Hawaiians/Pacific Islanders, and more than 50% are from under-represented minority groups. Through this project, a long-term retention of >80% of Akamai undergraduate interns in STEM degrees and careers has been accomplished, an important outcome when compared to national STEM graduation rates (<40%). More than 100 alumni are now in STEM jobs (2/3 in Hawai'i), and a steady flow continues to enter the workforce.

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Archival Publications (published) during reporting period:

Inverness Research, Inc. (2014) "The UCSC Institute for Scientist & Engineer Educators: Supporting Multi-Level STEM Workforce Development" Inverness, California. Available at: http://inverness-research.org/abstracts/ab2014-06_Rpt_Akamai_Briefs.html.

Inverness Research, Inc. (2014) "Contributions of the Akamai Workforce Initiative" Inverness, California. Available at: http://inverness-research.org/abstracts/ab2014-06_Rpt_Akamai_Briefs.html.

Inverness Research, Inc. (2014) "The Design and Implementation of the Akamai Workforce Initiative" Inverness, California. Available at: http://inverness-research.org/abstracts/ab2014-06_Rpt_Akamai_Briefs.html.

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Change in AFOSR Program Manager, if any:

Ed Lee was original Program Manager. I believe there were several changes. Final Program Manager is Evelyn Dohme

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Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, \$K)

	Starting FY	FY+1	FY+2
Salary			
Equipment/Facilities			
Supplies			
Total			

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